VOL. XVI, No. 20. SEPTEMBER 25, 1919

THE JOURNAL OF PHILOSOPHY
PSYCHOLOGY AND SCIENTIFIC METHODS

THE DEFINITION OF LOGIC

OUR familiarity with the definition of logic as a science of the laws of thought makes it easy to forget that thinking is not something given with determinate characteristics like the elementary substances of chemistry. If questioned, we explain that logic is a normative science. Its purpose is to aid in attaining truth and its laws are fixed by their relation to that end. We repeat as fundamental the laws of "identity," "contradiction" and the "excluded middle." On the basis of these and similar laws we develop a technique, more or less perfectly, and consider that our task is completed. To be sure there is still the problem of induction, but Mill's methods, a few selections from the psychology of observation, and perhaps a few general remarks on the definition and methods of science cover that well enough. The conscientious teacher may be a little baffled at the scant power of this method to vitalize thinking. The selected fallacies of the texts may have been adequately conquered, but when he turns to newspaper articles, political speeches, and matters of current interest, which he is sure are rotten with bad thinking, the amount of grist for the logic mill is surprisingly small.

The difficulty seems to me to arise from a blind following of tradition as to the nature of logic. In the first place the process of thinking is not a separate and clearly defined activity of a special faculty. It is a phase of human behavior in response to situations presenting obstacles to direct action. In the second place, its successful culmination, the truth, is for us nothing but the final moment that prepares a course of action fulfilling expectation. Verification demonstrates that it actually does so. Now if we turn to human history, it is not difficult to show that the thought phases of human responses have not always been selected by the same principles and that the expectations that the culmination must lead to fulfilment, if it is to be valued as truth, are not always the same. In other words, if truth is a name for the desideratum of thinking, it has had many meanings and for each meaning there is a different method of thinking that can be called the best. In a generalized sense, the laws of logic are the generalized description of procedures that have been

believed (proved?) to be successful in attaining a desired outcome of thought and that desired outcome is called the truth.

Among primitive peoples there seems to be retained a survival of a way of thinking in which interpretation in harmony with tradition is accepted as truth. In this stage men are impervious to experience. That is, the failure of events to conform to statements does not make them reject the statements but rather add more statements that attempt to link the exceptional cases with tradition and leave the former ones unmodified. Lévy-Bruhl[1] quotes a statement from Livingstone to the effect that after long discussions with rain-makers in Africa he never succeeded in convincing any of them of the falsity of their thinking. Another quotation reveals clearly the thought processes that are used: "On returning from the king's house I shot at a bird on a tree and missed it. I had taken quinine and my hand trembled. But the negroes who were there cried out that it was a bird-fetich and that I *could* not hit it. I shot again and missed again. Triumph of the spectators. However I loaded my gun again. I aimed with care and I hit the bird. A moment disconcerted, the negroes explained that I am a white man and that the laws of fetiches are not wholly true for me. So that my last shot proved nothing to them in the end." It is clear here that the aim of thinking is traditional interpretation and the enforcement of custom, for a native would not have tried to shoot the bird. Naturally with this conception of truth, experiment would not disprove the statement. The only disproof could come from rejecting the custom as bad and changing the habits of practises.

Lévy-Bruhl demonstrates conclusively, I believe, the complete difference between the type of primitive thinking and ours, although I think he hardly grasps its full extent. Our thought and observation are so thoroughly controlled in general by the ideas of the subject and objective, of the uniformity of nature,[2] and of universal causation that it makes us almost incapable of understanding thinking where these ideas are not sovereign. Yet it is not unusual to find violations of the principles of identity, contradiction and the excluded middle at the primitive stage. The one law Lévy-Bruhl lays down is that of "participation," but he calls the whole process "pre-logical." It is more expedient, however, to recognize it as a different type of logic controlled by a different aim. Also it has not been wholly superseded as any student of *Science and Health* or other contemporary mystical publication can testify.

[1] *Les functions mentales dans les races inférieures,* p. 62.

[2] Poincaré believes this derived from watching the stars and Cornford tries to show that it was, for the Greeks, a carrying over of habit and custom from social practises.

Unfortunately we can not trace the historic continuity of our thinking, in any adequate fashion, to early types parallel to those we now study in the lower races. The pre-philosophic stages of Greek thought suggest, however, something not far different. At the beginnings of Greek philosophy the integration of experiences into ideas having close resemblance to those dominating our thought processes is well under way. But it is probable that we exaggerate the resemblance. It would be interesting to know how Plato would react to the expositions of his thought current in the modern philosophy classroom. We attempt to define Greek scientific aims and assert that Greek scientists sought the permanent behind the changing facts of perception, but there is no adequate articulation of the method by which this is attained. Plato escapes the problem by the doctrine of reminiscence helped out by suggestions from perception and the Socratic comparison of particular instances. Aristotle's epagogic is little more than the process of taking away specializing differences and moving by formal analysis to the most universal. The outcome intended is the interpretation of factual experience through an unified system of ideas in a form suited primarily to esthetic contemplation. The modern idea of increasing man's mastery over his destiny is not yet born.

The result of Greek thinking was the emergence of so many ideas that have been incorporated in contemporary thought processes that it is easy to forget the vast differences implicit in their type of thinking. They should be manifest from the nature of Aristotelian logic, but the intensity of our gratitude to Greece and the still prevalent yearning for authority has led us to try to repeat the old logical forms and believe that they must be expressing something vital in our thinking. We bravely set forth examples of syllogisms and fallacies, but we must recognize that our conclusions are rarely attained by such forms. The real problem that generates Aristotelian logic is the problem of disclosing a relation between the particular and the universal. For this purpose rigid definitions, formal propositions, and syllogisms are pertinent. This problem is still with us when the results of our thinking must be displayed, but it has now become a problem of exposition rather than of discovery. Hence the method which Aristotle conceived as that of thinking, a method of logic, is now a method of rhetoric.

Medieval thinking faces a problem somewhat analagous to that of the Greek and readily accepts the Aristotelian system. There is a difference, however, and that difference introduces changes into the logic. The purpose is still fundamentally contemplative, but instead of an unified system of ideas derived from experience, the outline, or

norm, of the system is derived from orthodox texts. The Socratic method and the epagogic are minimized. Revelation takes the place of reminiscence. The metaphysical aspect of the relation of the universal and the particular is emphasized, but formally it is the linkage of statement with statement that is sought. Hence that appearance of artificial schematization that so many writers on logic have since condemned as a debasing of the Aristotelian procedure. It is not really this, but a modification consequent upon the change in the conception of the function thinking is expected to fulfil. This function may seem to us less significant but the method can only be judged from its adequacy to the desired result and, so judged, it is no less efficient than the earlier one. Both Greek and scholastic aims still sometimes motivate contemporary thinkers and for them at such moments these logics are still good.

Roger Bacon leads those who proclaim a new motive for thinking. If his proposed inventions are to be realized, thinking must become something quite different from the processes his contemporaries professed to esteem. It was the merit of Francis Bacon to set forth the claim of experience, and if his method of induction failed, it is perhaps because in his haste for utility, he was caught by the dogma of the universal equality of minds. He had still to learn that minds have a history and that their efficiency depends both upon native endowment and the cumulation of experiences, that they are not extra-physical complete instruments, but must extend themselves into all sorts of laboratory apparatus which thus become integral parts of the process of thought.

Since Bacon, logicians have contented themselves with varied attempts to juxtapose induction and deduction in a single system. The rapid lapse of modern philosophy into German scholasticism in the service of a new orthodoxy, and the authority of that philosophy, did much to retard the development of the new conceptions of thought. But outside of philosophy scientific work progressed and the phrase "methods of science" has become increasingly popular. John Stuart Mill, because he was skilful in depicting the differences between the actual procedure of sciences and the methods of traditional logic, was the unconscious instrument by which many have come to see that the fulfilment of the aims of modern thinking can not easily be defined significantly through generalized method. If prediction and control are the ends of thinking, thought becomes a function of the subject matter to such an extent that it can not be isolated with profit to logic. If there is to be a modern logic it must be primarily a logic of investigation. Beginning with the picture of the new attitude of mind implied by the thirst for the results of ap-

plied science, its laws must be articulated from the concrete procedures of scientists, inventors and social innovators. But apart from the subject matter with respect to which they arise, these laws can hardly be understood or applied.

Such a logic is the instrumentalist logic. It has not yet found its way into logic texts in any adequate form and perhaps can never do so. If we neglect the emasculated scholasticism, pieced out by somewhat obvious comments on induction, current to-day, its chief rival is the neo-realistic logic. This system has at least the merit of seeking scientific exactitude and completeness in the modern sense. It is not, however, a method of thinking although it is an instrument that a thinker can use. It can only be called logic if the term is to take on an entirely new connotation. There is, of course, no inherent difficulty in so transforming a term, but whether it would be expedient to do so in this case depends upon the extent to which the new procedure is applicable to scientific procedure. There is a strong historic presupposition that logic must somehow be an interpretation of the best, that is, of scientific knowledge. It must make for the attainment of truth in whatever way truth is defined. A mechanics of rearrangement such as Jevons's "logic" machine or the modern computing machines can hardly be said to exhibit logical processes unless we are prepared to call steam engines and automobiles that run examples of logical processes, a perfectly possible thing but hardly clarifying.

The presupposition of realistic logic is the reduction of experience to terms and relations. Leibniz saw more clearly than the modern partisans that the first necessity is that of a new dictionary in which every object can be so precisely defined that for a system of relation it can be forgotten and a devitalized algebraic letter substituted for it. Whereas he was limited to relations of inclusion and exclusion, modern research has substituted a more rich and flexible system of types of relations, the asymmetrical, transitive, the diadic, triadic and the like. When these relations are few in number a small group of postulates may suffice to define fundamental connections. The method then consists in devices for making manifest the relations that are also present according to the postulates when any two or more entities or groups of entities are given. Such expansions may actually fall within the class of discoveries for it is not always obvious what is really given with the fundamental assumptions. Professor Royce used to be fond of reminding his classes that it took two thousand years to show that when you had given the ideas of the square and of the circle, it was also established that a square could not be constructed by ruler and compass methods having an area

equal to that of a given circle. But is such a discovery quite the equivalent of the discoveries of the properties of radium or of the conditions under which communistic undertakings will be successful? This I doubt, although the connections between the fundamental factors and the conclusion might be exposited by an analogous system.

It is a curious thing that this conception of logic should have come into vogue and attained a high development after the doctrine of evolution had taken such a firm hold on scientific thinking. As Professor Dewey points out in his essay on "The Influence of Darwinism," it is precisely that notion of fixed kinds and abiding essences which lies behind the conception of terms for this logic, that is destroyed by the theory of evolution. The modern scientific problem of definition is that of selecting recurring and identifiable objects with properties that make verifiable predictions possible. The predicting gives little trouble, but not so the discovery of significant properties, or, sometimes, the process of verification. This logical method, though it theoretically should aid the process of prediction, is practically rarely applicable until the problem is solved.

The realistic logicians are fond of asserting that mathematics is nothing but a branch of formal logic. It would be, perhaps, truer to assert that their logic is nothing but an extension of mathematics. They have made clear for the first time the explanation of the possibility of applied mathematics and the use of diagrams in all sorts of fields. This is through the conception of types of relations. If mathematics deals with mere symbolized terms and sets of relational types, naturally whatever is true of these types is true of concretely specified relations that fall under the types, and one set of specifications, such as spacial relations, can serve to represent another, such as movement of prices. Historically mathematics attained its generalizations from the study of what could be counted or measured. It has extended this field to include relations of spacial objects involving other relations sometimes called qualitative. But the new system gives for the first time the generalized method that indicates the course and procedure of all further expansion. The question of the application of realistic logic is then the question of the limitations of applied mathematics.

The mathematical method represents an ideal (*i. e.*, utopian) structure for scientific knowledge. In so far as any investigated field can be reduced to a system of clearly defined entities, not too great in number, and fundamental relations between them abstractly formulated, mathematical derivation of all implied consequences is possible. If there were a few hundred variables and a corresponding number of relations, the technique would become too complicated to

be practicable. The definitions must give an exhaustive list of the properties of the entities in so far as they enter into effective relations within the system in question. With problems of physics and engineering these demands have been sufficiently met. By the use of statistical methods and probabilities, it is possible to make some allowance for factors not observed or the operation of which is not completely understood and the useful application of mathematics extended. Unfortunately in the biological and social sciences, it is not always easy to tell what are fundamental entities or what are their effective properties for situations that are to be met. Hence the application of mathematics makes little progress.

The structure of the physical world parallels the structure of mathematical systems but with some significant differences. In geometry, points are comparatively simple entities. In proper relational systems they are approximately equivalent to lines, although lines have a new quality, direction; lines define plane figures, with a few new properties such as shape and area; planes define solids; *etc.* So in the physical world, from comparatively simple electrons are constituted about 80 different atoms representing different numbers and arrangements of electrons. From these atoms are constituted numberless molecules; from these, aggregated states of matter; from these, probably, protobion, and so on through the cell, organism and multiorganism. In each case, as in geometry, the new entity is constructed from those that are simpler, but as a result of their integration in it new properties appear. There are, however, three striking differences when we compare this system with the mathematical one. In the first place, the number of new properties that appear at each level of integration in the system of nature is vastly greater than in the mathematical system. Hence the number of new definitions required at each step is greatly increased. A single property, direction, gives the new quality of any line, but several new properties would be required to give the new qualities of any atom, affinity, valency, mass, *etc.* In the second place, the first entities of the mathematical system are so highly abstract that all integrations of them permitted by the original postulates are equally possible, whereas in nature the frequency and conditions of occurrence are controlled, atoms of all possible sorts are not generated arbitrarily or in equal numbers. Thirdly, in mathematics we are fundamentally interested in the relations of entities on the different levels, while in nature we are interested especially in the processes whereby integration takes place.

The above strictures on the field of applied mathematics are not meant in any way to detract from its importance. Nothing could be more absurd than to try to belittle a technique by which mankind has

achieved such important and beneficial results both in practical and theoretical matters. They are, however, of significance when it is a question of judging the pretensions of a mathematical system to set itself in the place of logic. Unless this term is to be used in a wholly arbitrary sense, it should denote either the procedure of science or the methods of thinking by which truth, in some specified sense, is obtained. The mathematical system is only one of many instruments in the hands of the scientist and partakes more of the nature of a mechanical process than of concrete thinking. Mechanical thinking may be a moment in the thought process under favorable conditions, but it is far from being the equivalent of that process in general.

The most difficult problem for thinking to-day is that of making an analysis that shall result in the identification and selection of those factors in a given situation that can be taken as an equivalent of it for the purposes of prediction and control. We can not be sure that such factors have been obtained until we have verifications. But only then can they be genuinely symbolized as mathematical entities. Our texts still teach that we first formulate them hypothetically, deduce consequences by a sort of mathematical logic, and then seek verifications. Examples can be adduced, but they are usually taken from the field of applied mathematics. Professor Dewey incorporates this suggestion in the analysis of examples of thinking in his very suggestive little book, *How We Think,* but in actually analyzing the examples, this moment of thinking does not stand out very clearly. What seems to happen is that the idea of the problem and the previously acquired information that is pertinent to its solution are juxtaposed mentally until there results a sort of integration into a new idea all ready to use. Such integrations are accepted and lived by until we find ourselves again in difficulties and then new integrations are needed. Verifications are exhibitions of the potency of the new idea and although the connection between antecedents and consequences in such cases can be exposited deductively, the plan of verification is more likely to arise non-deductively during the psychological process of integration.

With our present preference for the instrumentalist conception of truth, in practise, if not always in theory, it seems unwise to limit logic either to the analysis of certain mental processes or to the objective techniques of the sciences. Perhaps it is too early to forecast what form this logic will take, what principles it will find it expedient to articulate. We need both psychological studies of investigators and empirical studies of investigations. There are some indications that the conception of mental integrations will baffle attempts to formulate the thinking process in a way significant for method

except in so far as precautions concerning observation, memory, and the effects of predisposition and prejudice may be stated. It is equally probable that significant generalizations of scientific practise may fail because of too close association between the materials and the ways of handling them, except in so far as certain systems of classification and arrangement of materials are evident. And there remains the rhetorical problem of the exposition of the results of thinking which can still be served by the survivals of Aristotelian formulæ, although the formal fallacies must be conceived rather as mistakes in reference to materials cited than as errors in deduction. Thus undistributed terms usually indicate a genuine opinion that the whole of a class is involved in a relation, an error in fact and not in inference.

No final definition of logic can then be laid down. In the last analysis logic appears as a method for the attainment of ideas approved for some reason as true. But the grounds for approval can change and with them the conception of the means of attaining the end. Primitive, Greek, and Scholastic aims still obtain amongst us and the most that can be said is that our age most generally prizes the instrumental conception of ideas. Consequently the instrumentalist conception of logic is most pertinent to it. This logic is most at home in the region of applied science. It is naturally disquieting to the ultra-conservative, distasteful to the ethic temperament, and resisted by orthodox theologians, although in each case it may be bent toward the end. Mankind is now seeking consciously directed development, but if it ever again seeks stability, who can say what logic will then prevail? Logic, like all other philosophic desciplines, has its inception in social conditions and its justification in the fulfilment of needs. Its systems, like other systems within philosophy, are not discarded because they have been found to be false, but because they have become uninteresting when new social conditions have brought to the front needs they are unfitted to meet. Errors can undergo correction, but there is no antidote to loss of interest, although the inertia of habit may temporarily maintain both philosophies and social institutions beyond their day.

HAROLD CHAPMAN BROWN.

STANFORD UNIVERSITY.

PURPOSE

WHEN two dice are thrown on a table, we say that there are eleven chances out of thirty-six that at least one four will be thrown. There is a branch of mathematics given over to the calculation of this sort of chance or probability. But chance in another